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X-620-63-86

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OPERATIONS WITH AN EXPERIMENTAL SATELLITE

MAY 3, 1963

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XEROX $

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GODDARD SPACE FLIGHT CENTER
GREENBELT, MD.

OPERATIONS WITH AN EXPERIMENTAL SATELLITE

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1 May 1963

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Greenbelt, Maryland

NASA TMX-50,104

Operations With An Experimental Satellite

Abstract

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The operational aspects of an engineering type experimental satellite are considered in light of the techniques and procedures employed and experience gained in the successful in-orbit operation of the RELAY communication satellite.

Requirements for satellite command and real time telemetry data reduction and evaluation are emphasized and the actual system employed for RELAY is described. Real time checkout and evaluation of the satellite's wideband communication subsystem is similarly discussed. The manner in which these capabilities were employed is illustrated with specific examples given.

Need for a central operational control point is considered with specific emphasis on communication satellites. The operations center for RELAY is described and its functions detailed. The operational support communications, such as teletype, telephone and video monitor links, required to perform effective control of the satellite through the test and control station and coordination of the complex of ground stations is illustrated. Specific capabilities and potentialities of this center are detailed.

In addition, the procedure required to assure an effective schedule of experiments is given. The required monthly, weekly and daily plans for scheduling communication experiments and station participation are discussed and their relative importance explained.

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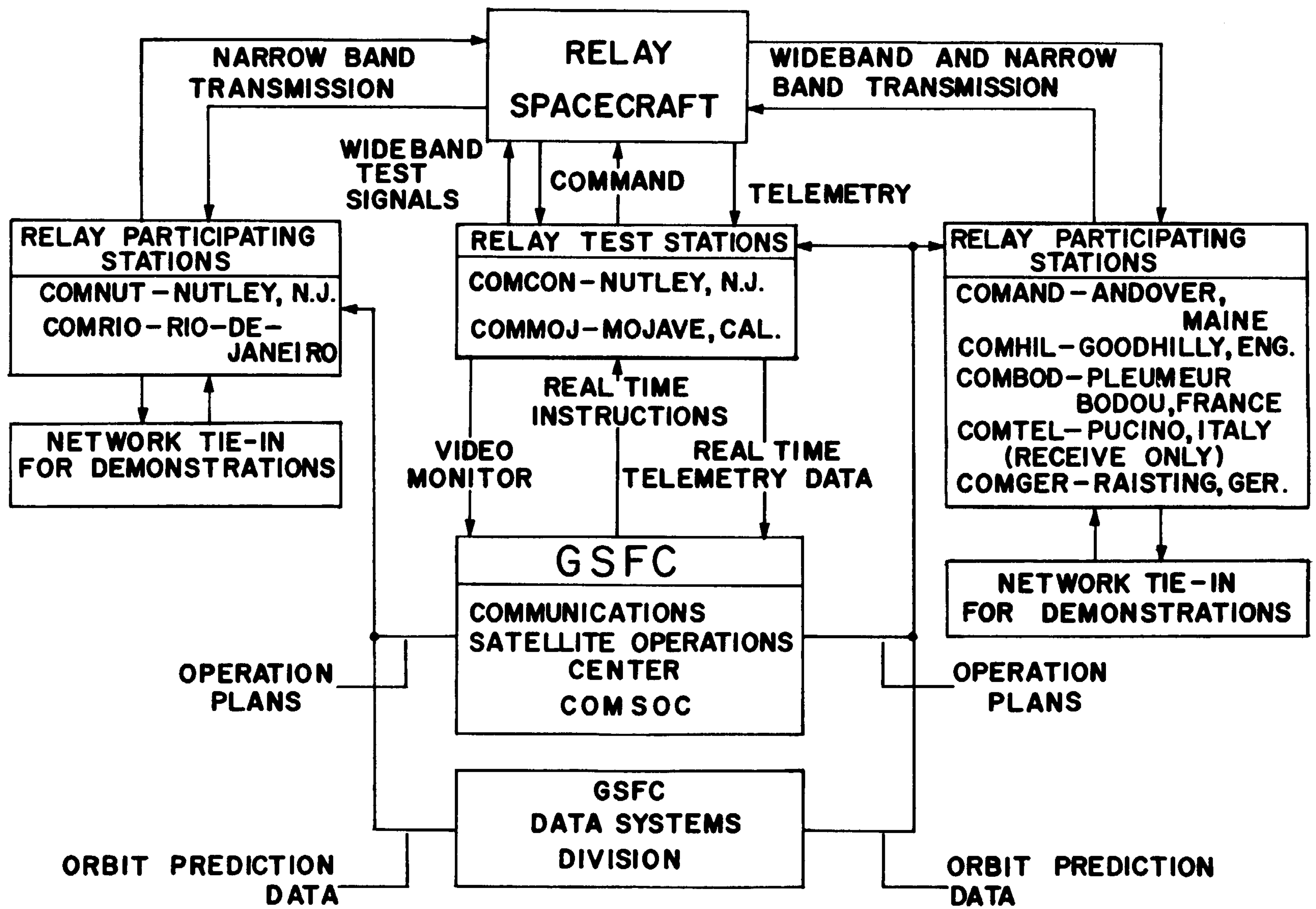
OPERATIONS WITH AN EXPERIMENTAL SATELLITE

In the design of an experimental satellite system the operational considerations are sometimes compromised or perhaps ignored to some degree. There is always interest in designing, building and launching new satellites but once in orbit the job is considered complete. The operations phase is left to some obscure group to turn on the telemetry system occasionally to gather data to be mailed to some location for automatic processing and storage for subsequent analysis at a later date. These are the procedures which often characterize satellites which are strictly scientific in nature. The operational considerations for an experimental satellite system such as RELAY are more critical in that because of power requirements it is necessary to monitor telemetry during each orbit pass that the wideband transponder is used. Additionally, the complex task of scheduling and conducting communications experiments with several different participating countries require full time attention. Some of these aspects as they relate to Project RELAY are discussed below.

Project RELAY is an experimental communication satellite program whose purpose is to demonstrate the feasibility of wideband and narrowband communications between Europe, South America and the U.S. using a low altitude repeater earth satellite. This system is comprised of the orbiting satellite, the participating communication stations in the U.S. and other countries, two GSFC control and test stations and an operations center. Figure 1 is a simplified block diagram of the RELAY system.

The external configuration of the RELAY spacecraft is that of an octagonal cylinder topped by an octagonal truncated cone. The cylindrical portion is 29.22 inches in diameter and 16.45 inches high. The truncated cone portion is 15.25 inches high and is shaped to conform to the shape of the Delta launch vehicle low drag nose fairing. With the exception of the upper and lower surfaces the entire spacecraft is covered with solar cells. The wideband communication antenna is mounted on a boom which extends 19 inches above the truncated portion of the spacecraft. Figure 2 shows the external view of the spacecraft. The spacecraft was designed to support a total of 100 minutes per day of the wideband communication subsystems operation. This total operating time was to be accumulated on 3 or 4 successful orbit passes and since the orbit has a period of 3 hours this operation would be covered over a period of approximately 12 hours per day. RELAY satellite also carries a radiation experiment package to determine the effects of radiation on solid state devices, in particular, solar cells, and to evaluate these effects in terms of life time of possible usage in future communications satellites. Thirty different solar cells are being tested in this experiment along with several diodes. Figure 3 is a cutaway diagram showing basic features of the spacecraft.

FIGURE 1 RELAY SYSTEM



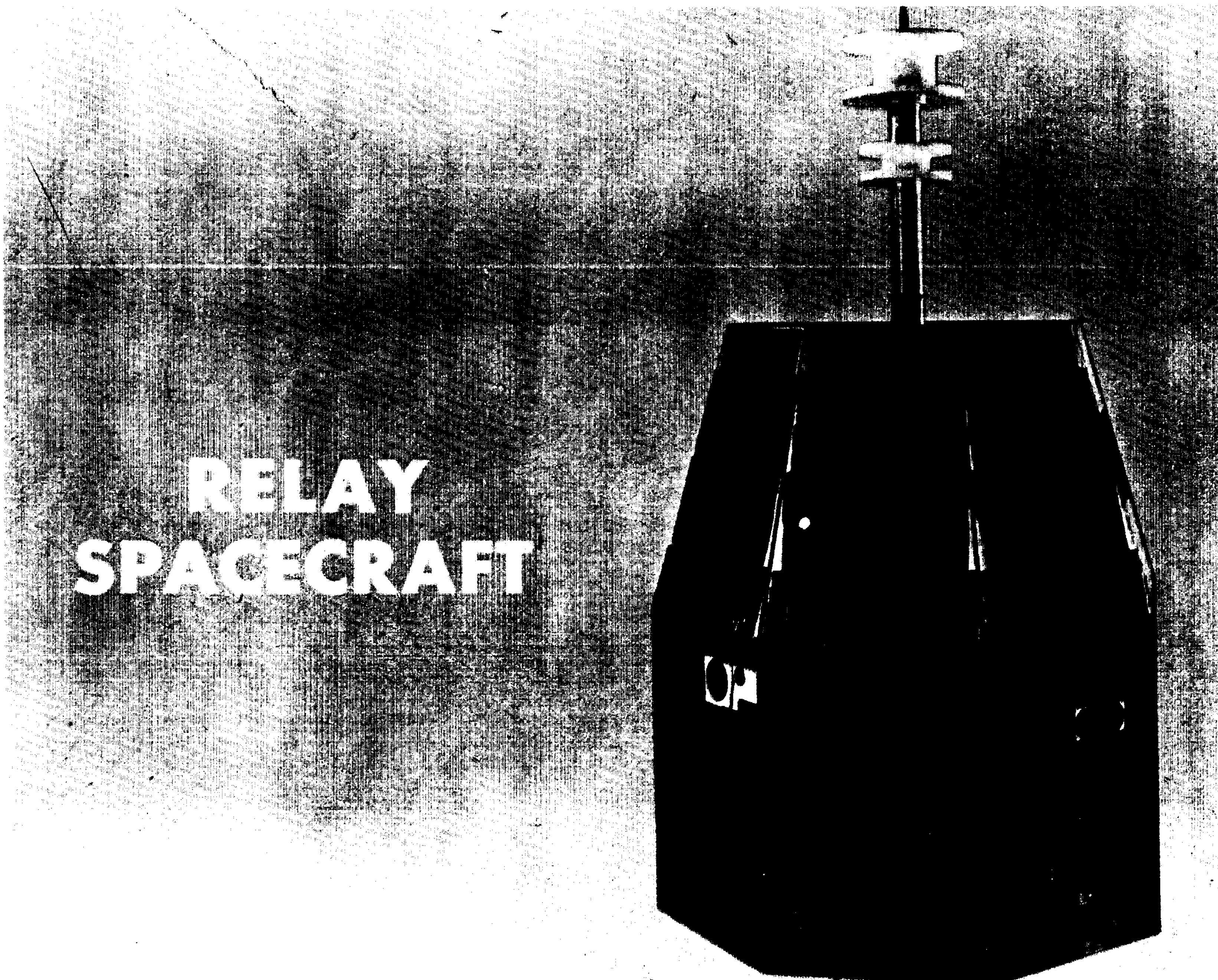
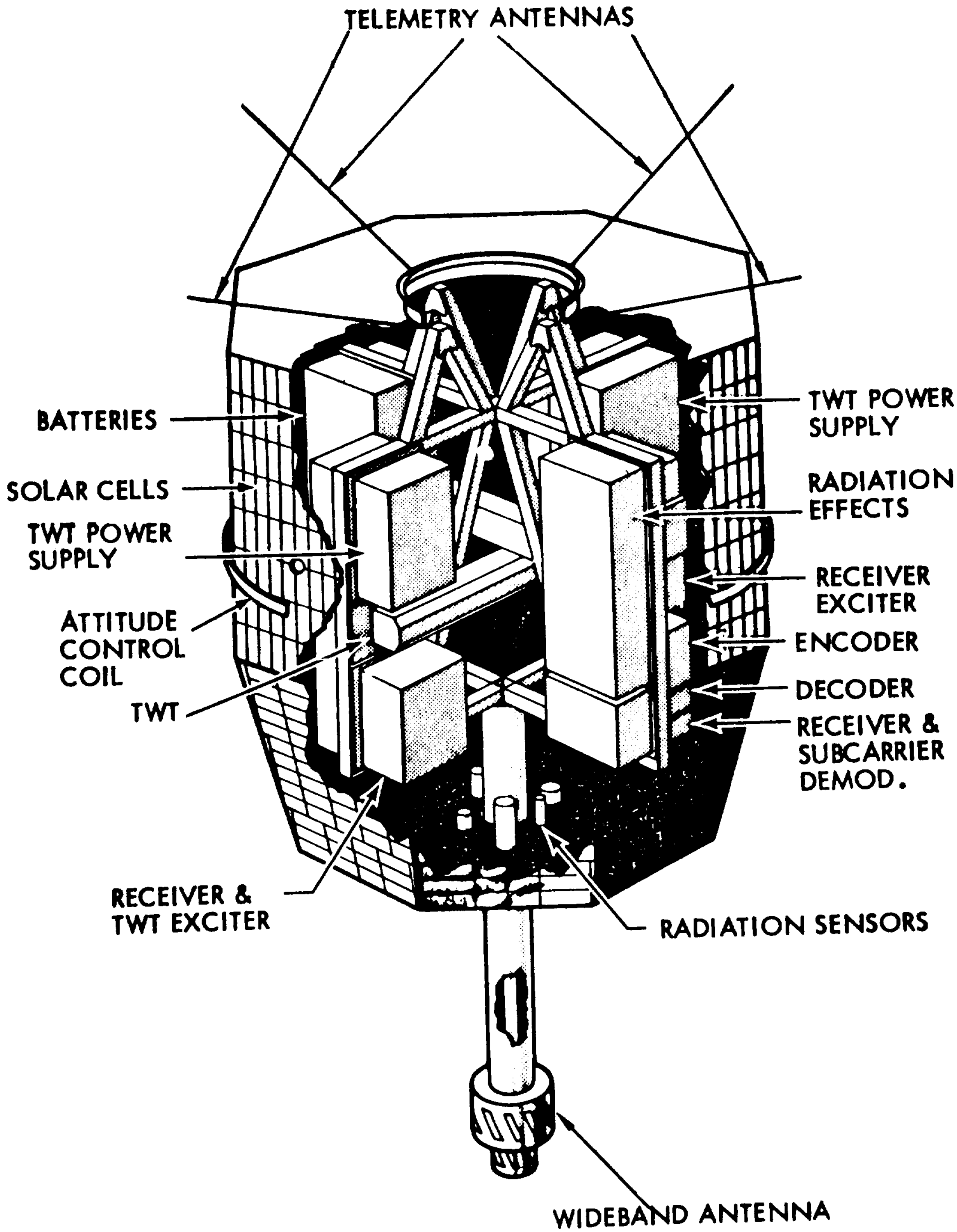


Figure 2



Project RELAY Satellite

Figure 3

RELAY I was successfully launched on December 13, 1962 in a nearly precise nominal orbit. Figure 4 gives a table of RELAY orbital characteristics along with the nominal values that were expected.

The participating stations consist of the American Telephone and Telegraph station at Andover, Maine (COMAND); the International Telephone and Telegraph station at Nutley, New Jersey (COMNUT); British Post Office station, Goonhilly Downs, Cornwall, England (COMHIL); C.N.E.T. station, Pleumeur-Bodou, France (COMBOD); Telespazio, Fucino, Italy (COMTEL); and Radional at Rio de Janeiro, Brazil (COMRIO). The Deutsche Bundespost of Germany is completing a station at Raisting, Germany which will be operational in mid 1964. The Japanese government is also participating in the program and will have a station with receiving capability in the latter part of 1963. The Andover, Maine and Pleumeur-Bodou, France ground stations are very similar and employ a 60 foot horn for wideband and narrowband transmissions and reception, and can either auto-track or be used in a program track mode. Figure 5 depicts the Andover Horn with the radome removed. The Goonhilly, England site employs an 85 foot parabolic reflector which does not have auto-track capability and tracks by means of program drive tapes. Figure 6 is a picture of the Goonhilly Antenna. Goonhilly is also used for both wideband and narrowband communications. The Fucino, Italy site does not yet have the capability of transmitting and is only used for wideband and narrowband reception. The ITT station at Nutley, New Jersey and the Rio de Janeiro sites are primarily narrowband stations and are used extensively for two-way narrowband communication experiments between U.S. and South America. Figure 7 is a picture of the Rio station.

The two GSFC control and test stations are located at Nutley, New Jersey and Mojave, California. The Nutley site shares the common antenna with the ITT station which is a 40 foot cassegrain antenna. This test station (designated COMCON for communications control) is contained in 2 mobile trailers which are joined to form a single unit. Figure 8 gives an overall view of the Nutley site showing both COMCON and COMNUT. A separate antenna is used for the command and telemetry functions performed by the test stations. The other test station located in Mojave California (COMMOJ) is essentially identical to the Nutley site with the exception of the wideband test capability and the communication antenna. COMMOJ utilizes a 40 foot parabolic antenna on an XY mount. (See Figure 9). The antenna used for command and telemetry purposes at Mojave is identical to the one employed at Nutley.

RELAY Orbit Characteristics

Item	Nominal	Actual
Height of Apogee	3999.48 nm	4020.70 nm
Height of Perigee	699.92 nm	712.13 nm
Period	184.36 min	185.09 min
Eccentricity	0.28475	0.28462
Inclination	47.766°	47.496°
Right Ascension of Ascending Node (injection)	217.22°	218.74°
Argument of Perigee (injection)	176.426°	177.5°
Nodal Rate	-1.2845°/day	-1.2779°/day
Perigee Rate	1.2030°/day	1.2123°/day

Figure 4

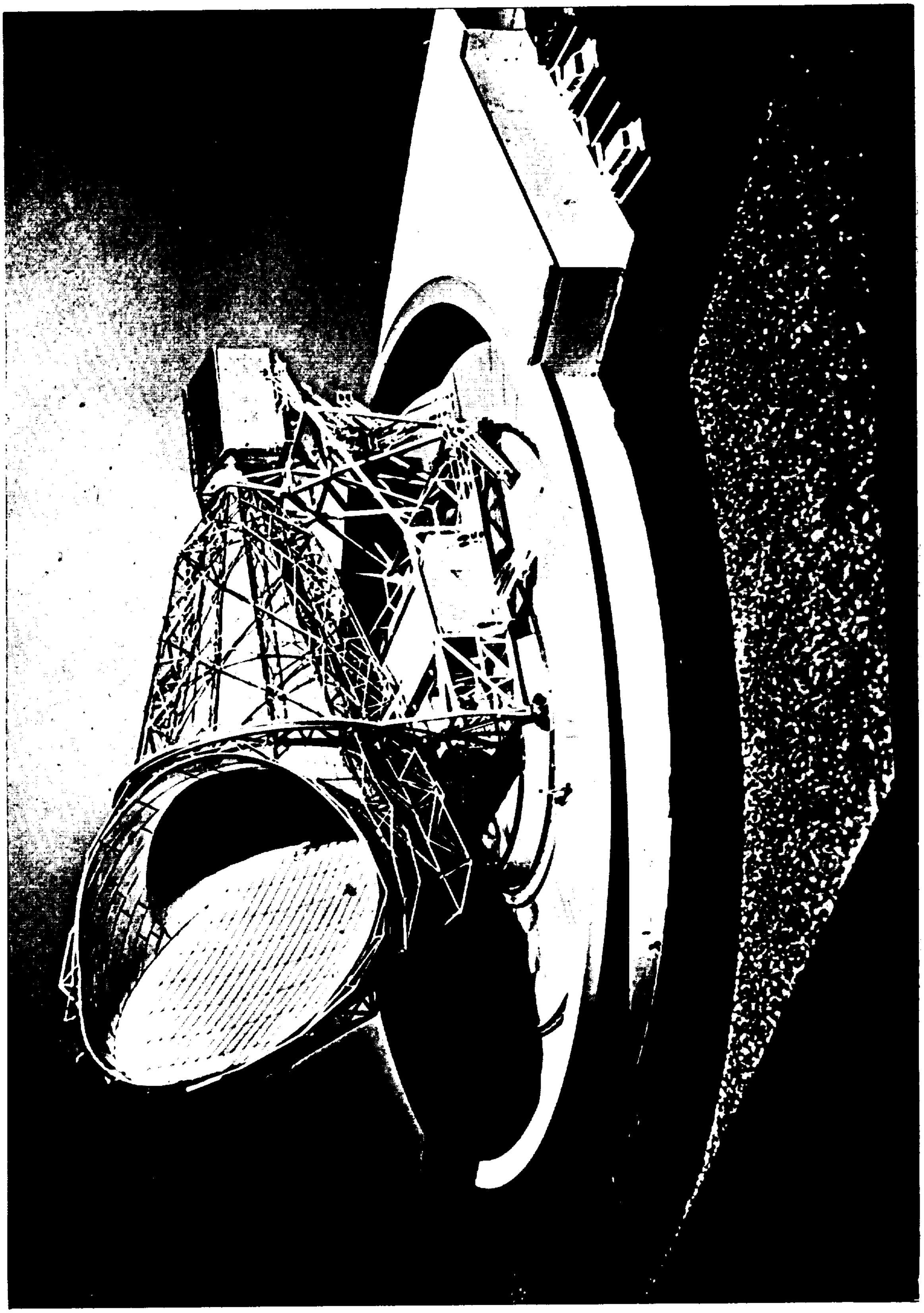


Figure 5 ANDOVER HORN ANTENNA

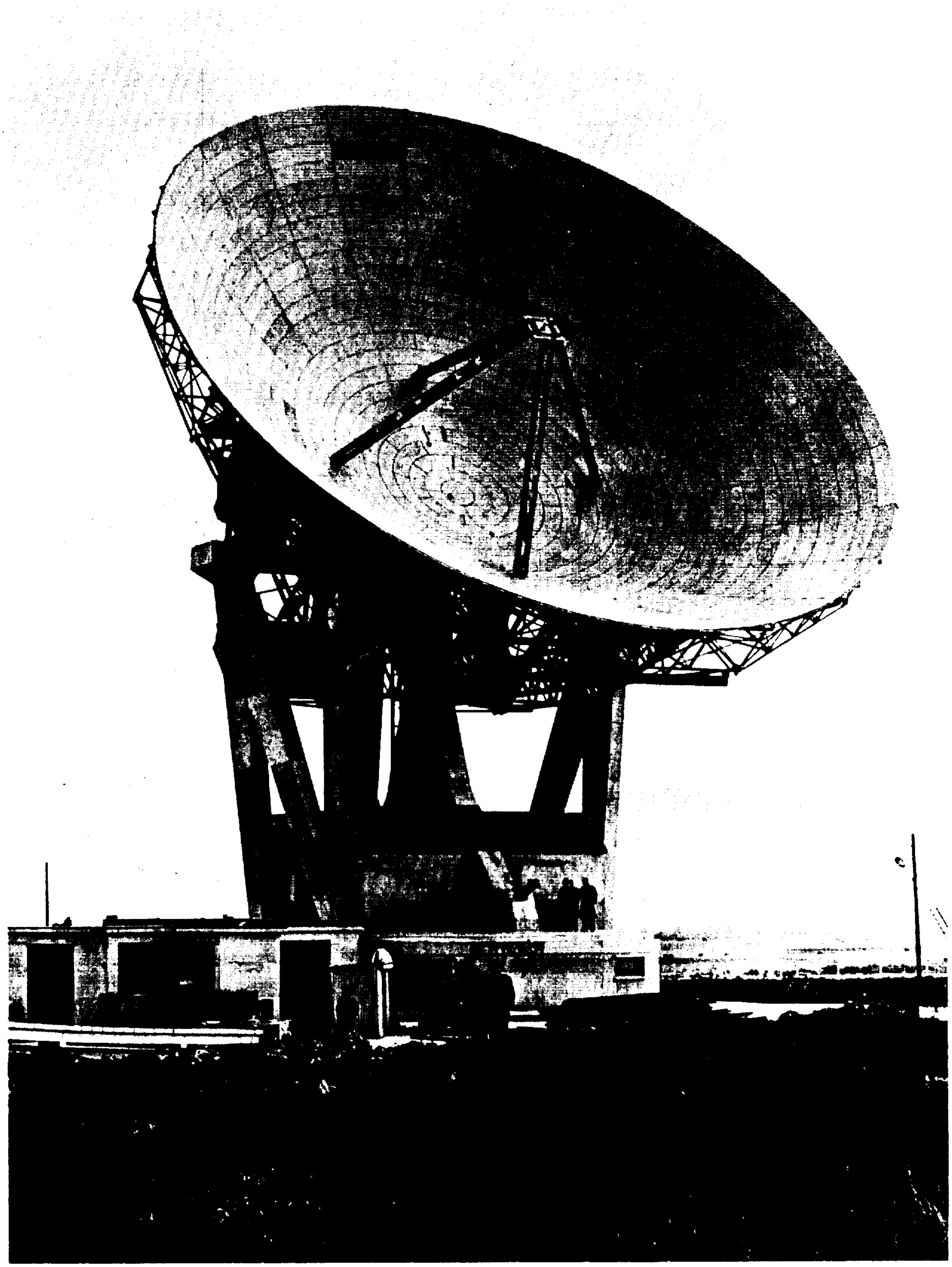


Figure 6 GOONHILLY ANTENNA

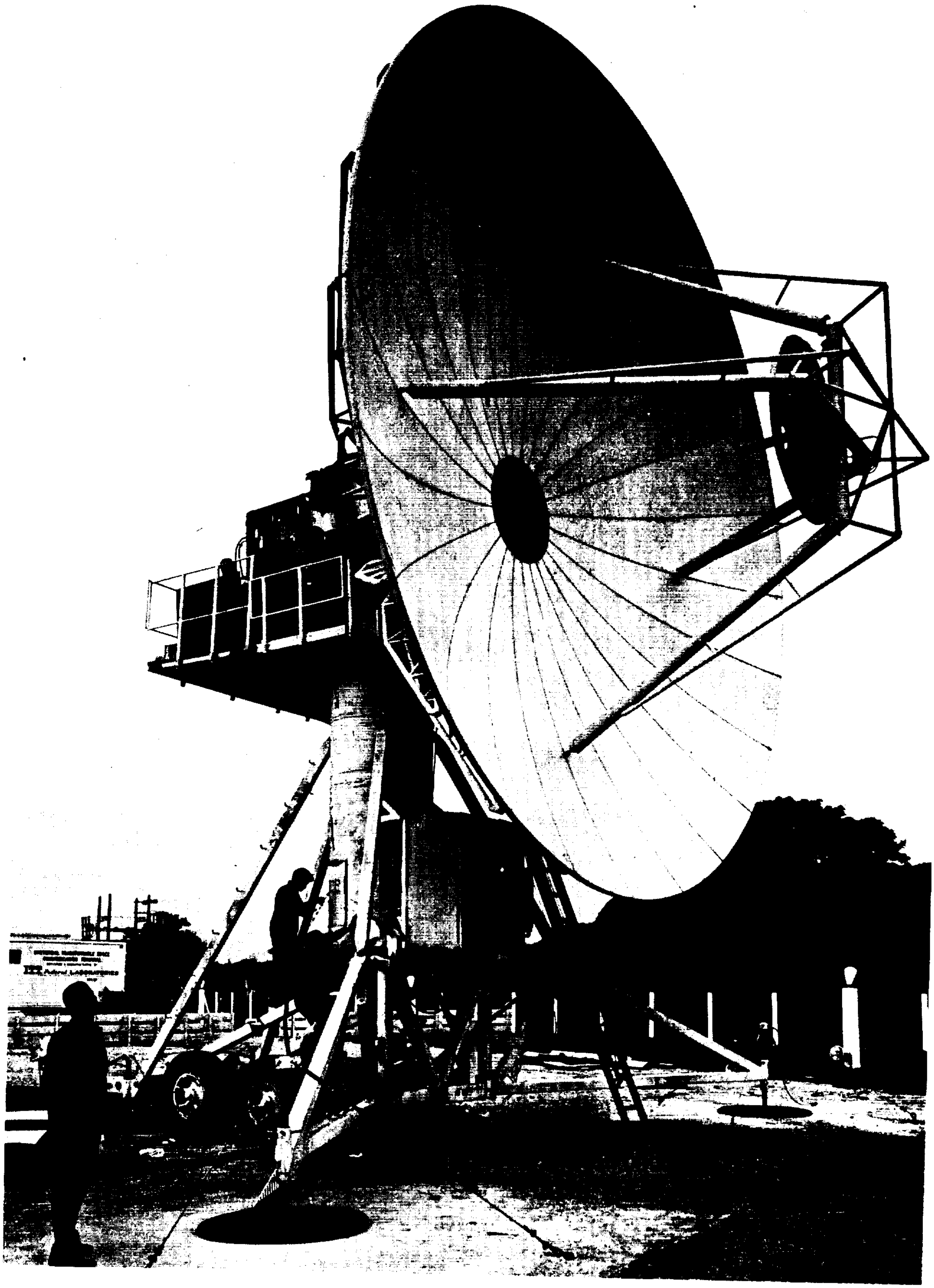


Figure 7 RIO de JANERIO STATION

Figure 8 VIEW OF COMCON AND COMNUT

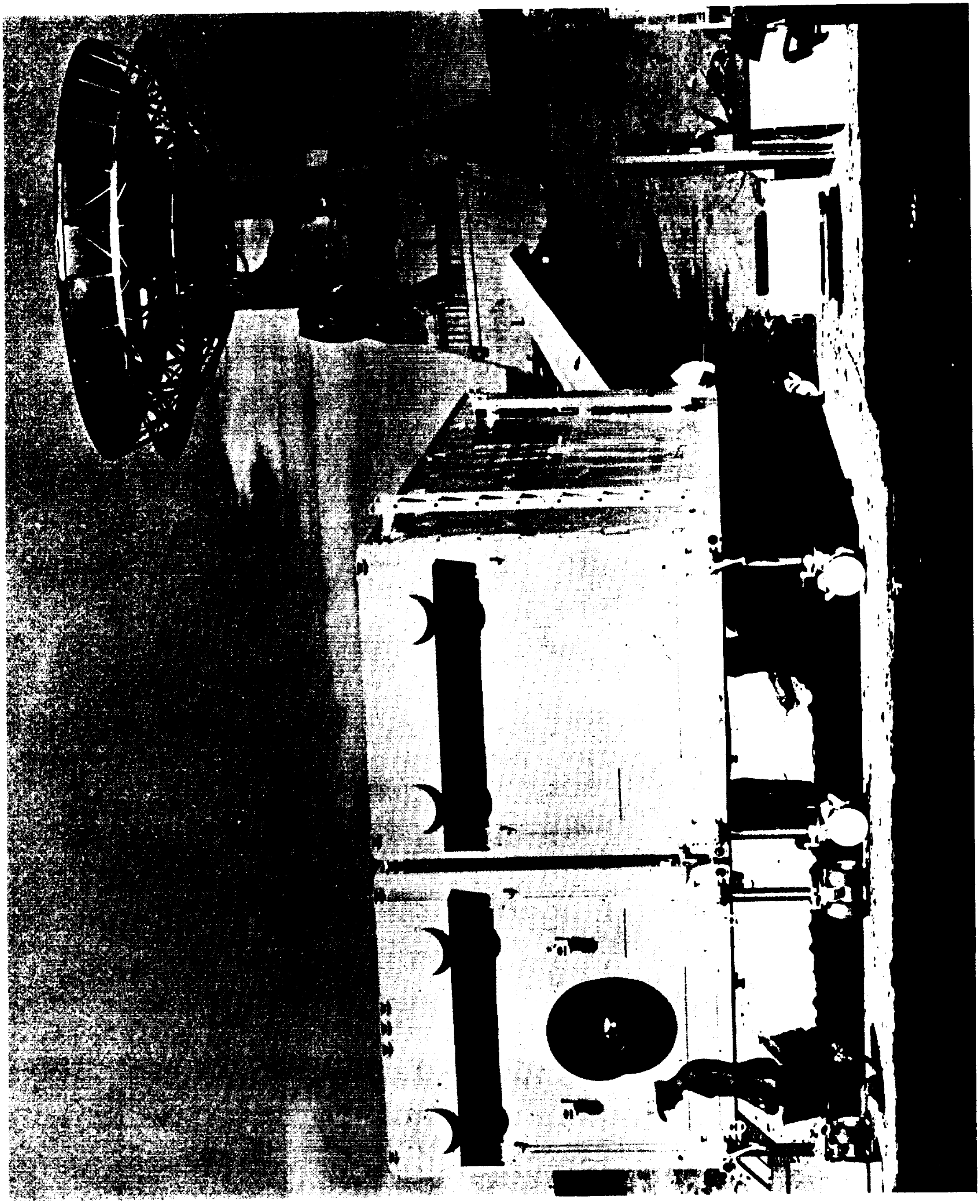


Figure 9 MOJAVE TEST STATION

The central point of the RELAY system is the operations control office at Goddard Space Flight Center. This office designated COMSOC for Communication Satellite Operations Center is used to direct all command and control of the satellite, evaluation of real-time data and as the office through which all communications experiment scheduling and coordination is conducted. COMSOC issues all operation plans and experiment schedules and acts as a clearing house for orbital predictions and correlated data. Figure 10 is a typical view of COMSOC during an orbit operation. Figure 11 lists the specific functions performed by COMSOC.

The RELAY satellite is operated daily on many successive orbit revolutions. Because of the practical size limitations on the power supply and since the wideband subsystem represents a severe electrical load it is necessary to exercise precise control in order to realize maximum utilization of available power. This can only be effected through the means of reliable command capability and real time telemetry data readout. These functions are performed by COMSOC utilizing the test station in a remote manner to provide the command and telemetry function at the direction of COMSOC. These functions become more critical when one considers the necessity for turning on the spacecraft at a pre-scheduled time in order that one or more communication stations can conduct experiments. The actual control of the satellite is performed by the COMSOC COMCON combination with direction being supplied by COMSOC.

Controlling the experimentation on RELAY is a continuous problem because each station has a diversified capability unique to itself. In addition, the variety of engineering communication experiments which were generated to be conducted are complex by their nature. These require adequate coordination so that the stations participating are assured of adequate test setup time. Of course, one aspect not to be neglected is that RELAY has the capability of supporting public demonstrations of television, teletype, facsimile and telephony. To make certain that these demonstration experiments are started at the precise time that the transponder is available, COMSOC has been used to cue the program network.

It is necessary to have full period teletype and telephone hook up between COMSOC and most participants. This is required in order to transmit the operations plans and summaries and routine operational teletype traffic. Pointing data supplied to all stations is also teletyped over these same circuits. The full period telephones are used for real time coordination and cuing during the operational passes. Figure 12 gives a block diagram of the ground communication network with COMSOC.

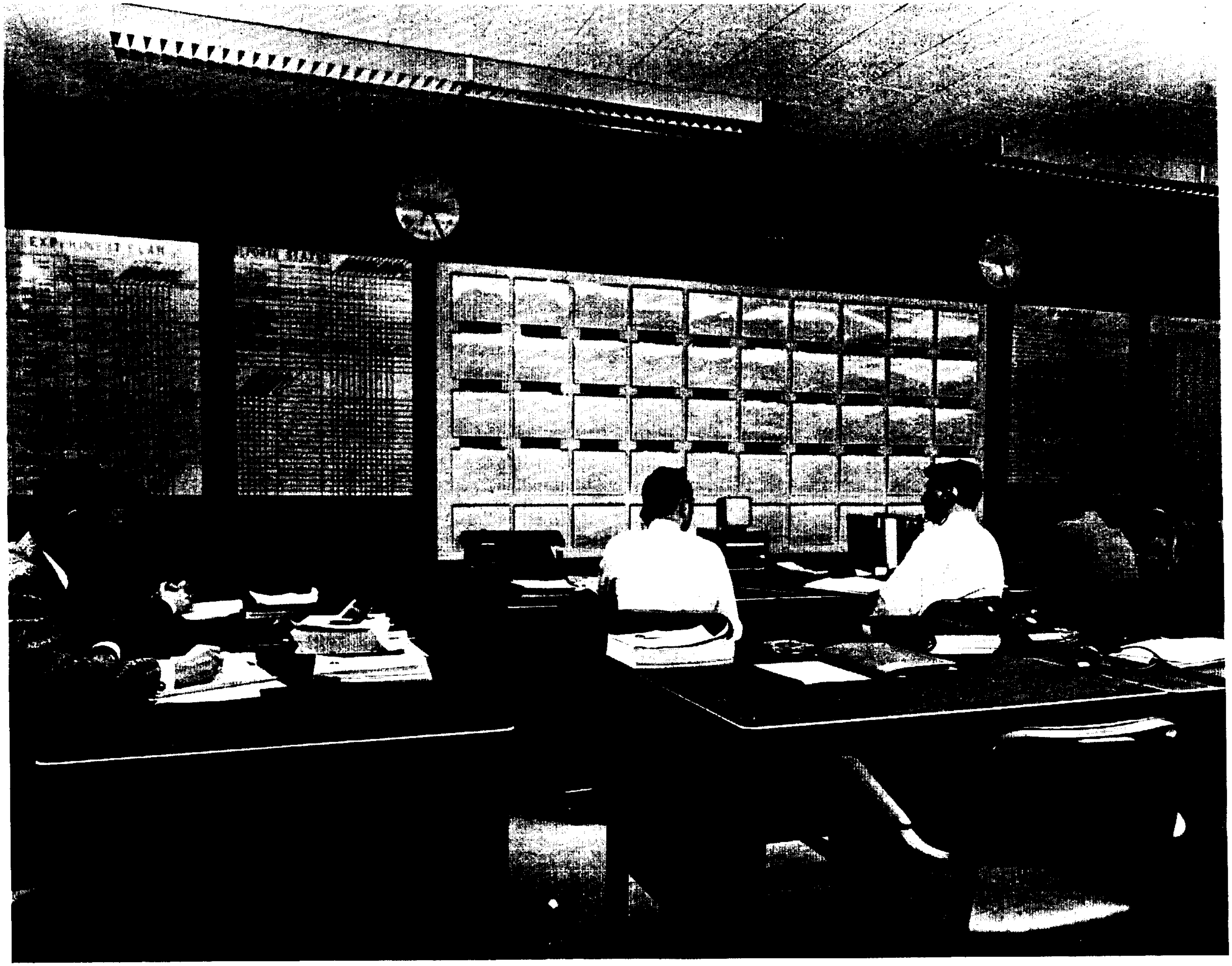


Figure 10 COMMUNICATIONS SATELLITE OPERATIONS CENTER

FUNCTIONS OF COMSOC

a. Perform Day by Day Orbital Operations of Satellite
b. Issue all Commands to Test Stations to Control Satellite
c. Maintain Real Time Contact with Participating Stations During Operations to Ensure Effective Coordination of Experiment Including Cuing and Hot Switching
d. Analyze Class II Data Both in Real Time to Effect Satellite Control and Over Long Term Periods to Determine System Deterioration
e. Coordinate and Issue all Monthly, Weekly and Daily Operation Plans
f. Summarize All Station Operation Reports and Issue Daily Summaries to Include Spacecraft Performance and Correlated Data
g. Act as Clearing House to Ensure Issue of Orbital and Pointing Data to All Participating Stations

Figure 11

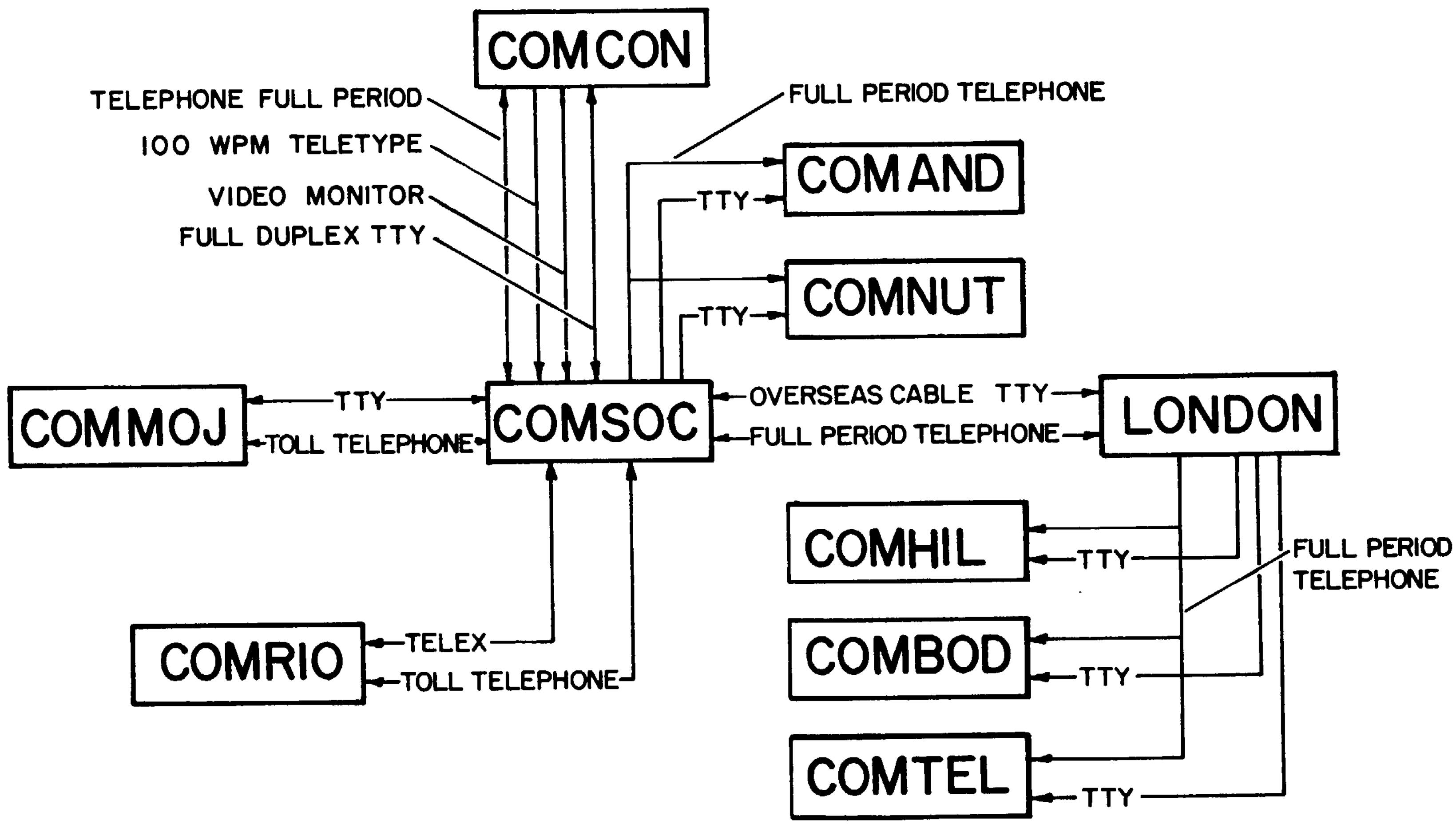


FIGURE 12 RELAY GROUND COMMUNICATIONS

Hot switching has been one other function possible with the use of COMSOC and the test station. This has enabled narrowband telephony tests between COMHIL and COMRIO followed by wideband television tests from COMAND to COMBOD during the same 30 minute pass. Less than 10 seconds switchover has been required. The transponder was commanded to the wideband mode at the pre-scheduled time with COMHIL and COMRIO instructed to cease transmission of carrier. At the same instant COMAND and COMBOD were instructed to commence television tests. These so-called Hot Switches were conducted several times between the communication station to illustrate a flexibility that allows maximum utilization of the available satellite visibility and transponder operation time.

The day by day operational planning and scheduling is performed at COMSOC in the following manner. An arbitrary assignment of operating days is made for each week by discussing the appropriate availability with each station. This leads to the generation of a monthly plan which assigns operational days to each station. The orbit is examined for this time period and the stations are scheduled by orbit pass number based upon adequate visibility between the participating station and COMCON. Since COMCON is used as the primary telemetry and command post, no passes are scheduled which are not in mutual visibility with COMCON. After assignment is made of particular orbit revolutions, the available spacecraft power, slant range, spacecraft look angles and elevation angle constraints are considered and an approximate time period for the experiment is determined. This time is then further modified by the amount of telemetry data that is desired to be examined prior to and after the wideband operation. Coordination with participants is conducted both with teletype and full period phone circuits until a detailed weekly plan can be generated. The resulting schedule is then teletyped to all participants to obtain their comments and inputs on RELAY experiments to be scheduled for the times indicated. A detailed daily operations plan, which incorporates all last minute changes and recommendations, is finally teletyped to all participants by COMSOC and actual orbit pass is conducted in accordance with this schedule.

All orbit data on RELAY is generated by GSFC based on tracking data from the NASA minitrack stations and spatial orientation based on horizon scanner information from the satellite. This information takes the form of pointing data predictions in terms of azimuth and elevation angles and spacecraft look angles for each station. The pointing data is used by all stations for satellite acquisition and antenna steering. The look angle data is used in calculation of satellite antenna gain in analysis of communication experiments. COMSOC sends the look angle data to the stations on a continuous basis and makes certain that the pointing data is also sent.

One important consideration which has attributed to the success of COMSOC is the orbit data that is available. Printouts of slant range, elevation angle, azimuth angle and spacecraft look angles for each station are maintained at COMSOC. These are listed for one minute intervals over the orbit revolutions for several weeks in advance. The high degree of accuracy of these data have allowed efficient scheduling of the experiments and has added much to controlling the operations.

As previously mentioned, COMCON provides the actual command function of the satellite. Further, the telemetry data is received and processed at COMCON for transmittal to COMSOC. In addition, it is necessary to perform loop tests with the wideband transponder independent of the formal communication experiments to determine if the wideband system is working as expected. These requirements dictate that the control and test station (COMCON) must have the capabilities listed in Figure 13.

The spacecraft's telemetry system consists of 2 telemetry transmitters which are redundant and a single encoder. The system is Pulse-Code-Modulated with 1152 bits per second rate. Each telemetry word is comprised of 9 bits and this results in 128 main telemetry words. A large portion of these are used to telemeter information from radiation experiments. Only 10 of the main frame words are used for monitoring spacecraft performance. Figure 14 shows the assignment of the main frame words. One of the main frame words (28) is submultiplexed into 64 channels. In all, this provides 73 telemetry items for monitoring spacecraft subsystem performance.

Figure 15 shows the telemetry receivers at COMCON. The telemetry transmitters on the spacecraft transmit on 136.620 mc and 136.140 respectively. COMCON is capable of receiving telemetry on either frequency.

The telemetry data has been separated into 3 categories; Class I, Class II and Class III. The first of these, Class I, consists of 11 items which are decommutated at the test station and displayed on the strip chart recorder for real-time evaluation during an orbit pass. Six (6) of these Class I items are further processed to provide signals through a limit checker which will give a green or red light indication at the test station to provide a rapid indication when these items are exceeding their expected limits.

The second category of data, Class II, consists of 39 spacecraft performance measurements plus 8 radiation experiment measurements which are processed at the test station by a Packard Bell 250 computer. This reduced data is teletyped in real time to COMSOC by

TEST STATION CAPABILITIES

a) DETERMINING THE OPERATING CONDITION OF THE SPACECRAFT BY MEANS OF REAL-TIME TELEMETRY READOUT AND DISPLAY

b) OBTAINING QUICK-LOOK TELEMETRY FOR DAILY MONITORING OF THE SPACECRAFT CONDITION AND TRANSMITTING THESE DATA TO THE OPERATIONS CENTER BY TELETYPE

c) RAPIDLY TESTING THE PERFORMANCE OF THE SPACECRAFT WIDEBAND COMMUNICATION SUBSYSTEM

d) CONTROLLING THE SPACECRAFT BY RADIO COMMANDS AS REQUIRED BY THE EXPERIMENT TO BE PERFORMED

e) CONDUCTING WIDEBAND EXPERIMENTS WITH THE SPACECRAFT

Figure 13

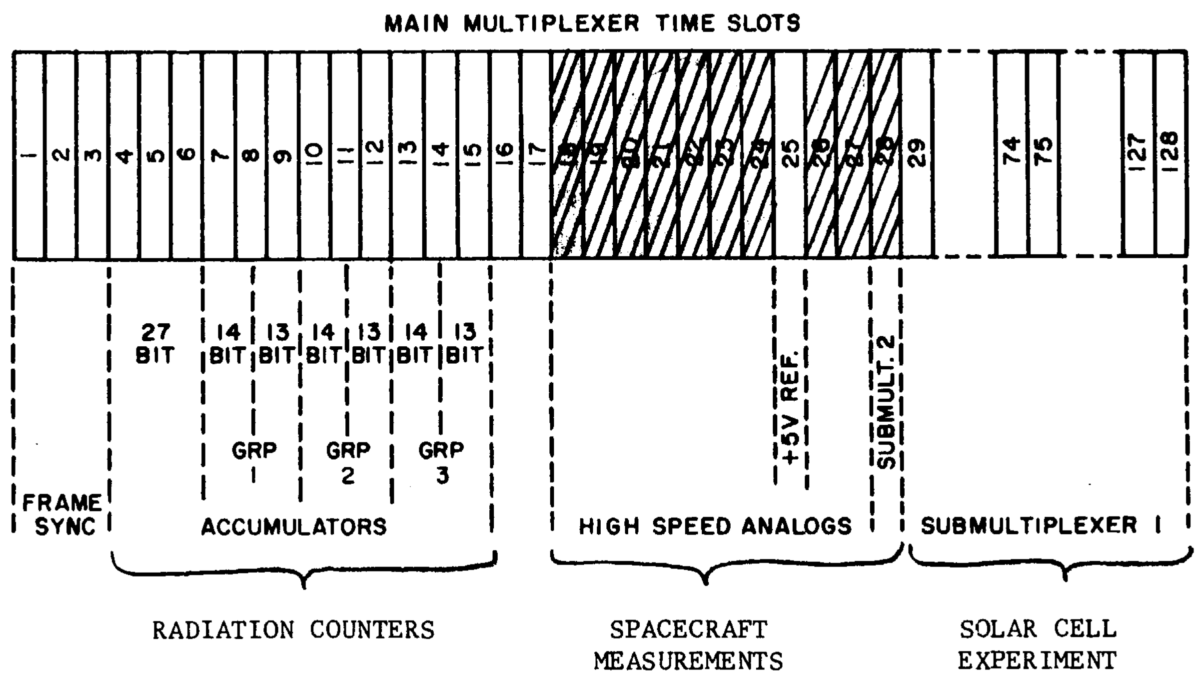


Figure 14 TELEMETRY MAIN FRAME WORD ASSIGNMENT

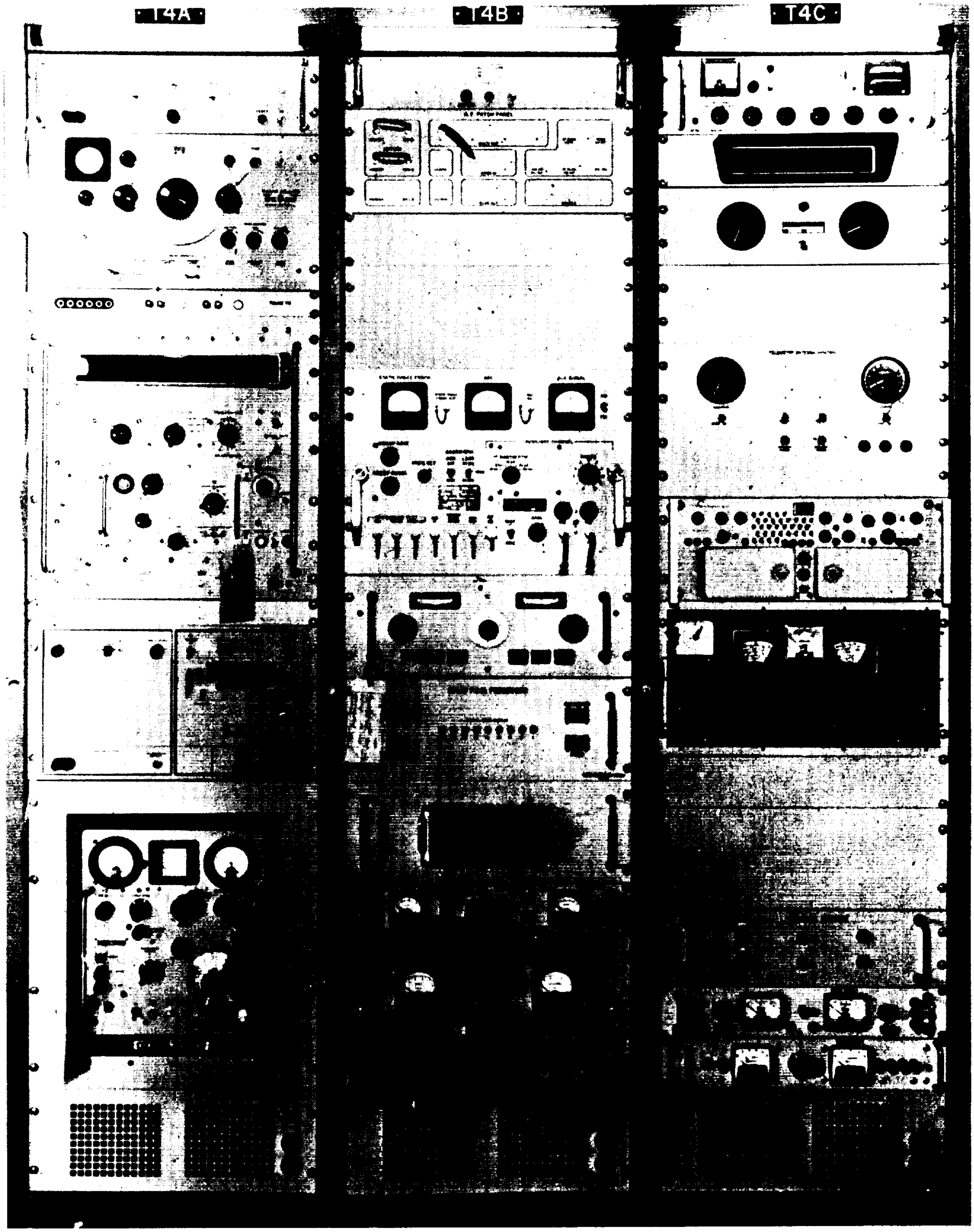


Figure 15 TELEMETRY RECEIVERS AT COMCON

means of a 100 word per minute teletype circuit. Figure 16 shows the PB 250 computer which takes the raw telemetry bit stream, senses and corrects for the zero and five volt calibration, multiplies by the necessary linear calibration to reduce the raw data to final printout. This output is printed on plastic tape which is compatible with the five digit code teletype format. A teletype tape distributer is located a few inches from the computer output tape. The tape distributer drives the 100 word per minute machine and provides the printout at COMSOC.

The remaining category of telemetry data actually consists of all of the received signals which is recorded as raw bit stream on magnetic tape for later processing and reduction by GSFC Data Processing Branch. Figure 17 shows the strip chart recorder for Class I and magnetic recorders for Class III data. Figure 18 gives block diagram of telemetry flow.

The Class I items have been selected because these represent the most critical measurements which indicate real time changes in the spacecraft condition. All the command verification voltages which are translated to command states of the spacecraft are also included. Figure 19 gives listing of the Class I items. Class I items can be decommutated and displayed independent of the Class II items. When difficulties with the computer are encountered making it impossible for Class II data reduction and printout, and subsequent transmittal to COMSOC in real time, the passes have been conducted using Class I data exclusively.

The real time reduction of many spacecraft performance measurements as are included in Class II (see Figure 20 for listing of Class II data items) becomes the real significant operational tool for experimental satellites. Utilizing this capability has allowed us to accumulate performance data in real time while critical functions were being conducted on the spacecraft. It has enabled real time verification of the command states of the spacecraft which gives one the opportunity for correcting anomalous command states if they should occur. It also allows real time verification that commands transmitted to the spacecraft were successfully received. Of course, the telemetry items themselves provide additional verification when subsystems are operating thereby supplying proof that commands were received and acted upon successfully. The Class II data provides a printout of 39 spacecraft performance measurements which include the 4 command verification voltages and also the printout of 8 items from the radiation experiment package. Seven (7) of the 39 items are main frame words and 6 of these are printed out every 16 seconds. The remaining 32 items are submultiplexed channels of main word 28 and are printed out each time they are sampled in the spacecraft or at a rate of every 64 seconds. Figure 21 shows the typical format of the Class II data printout.

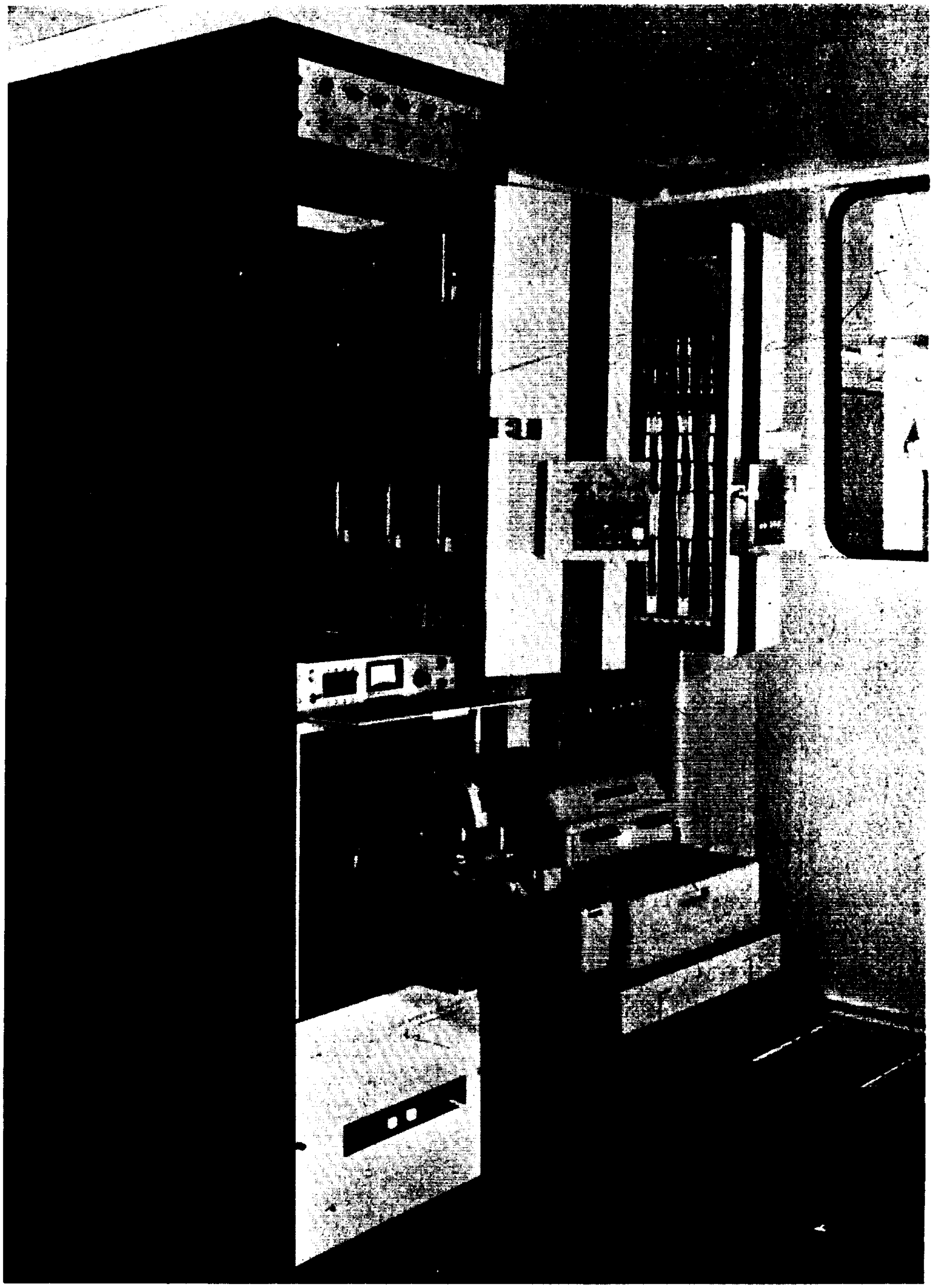


Figure 16 PACKARD BELL 250-COMPUTER

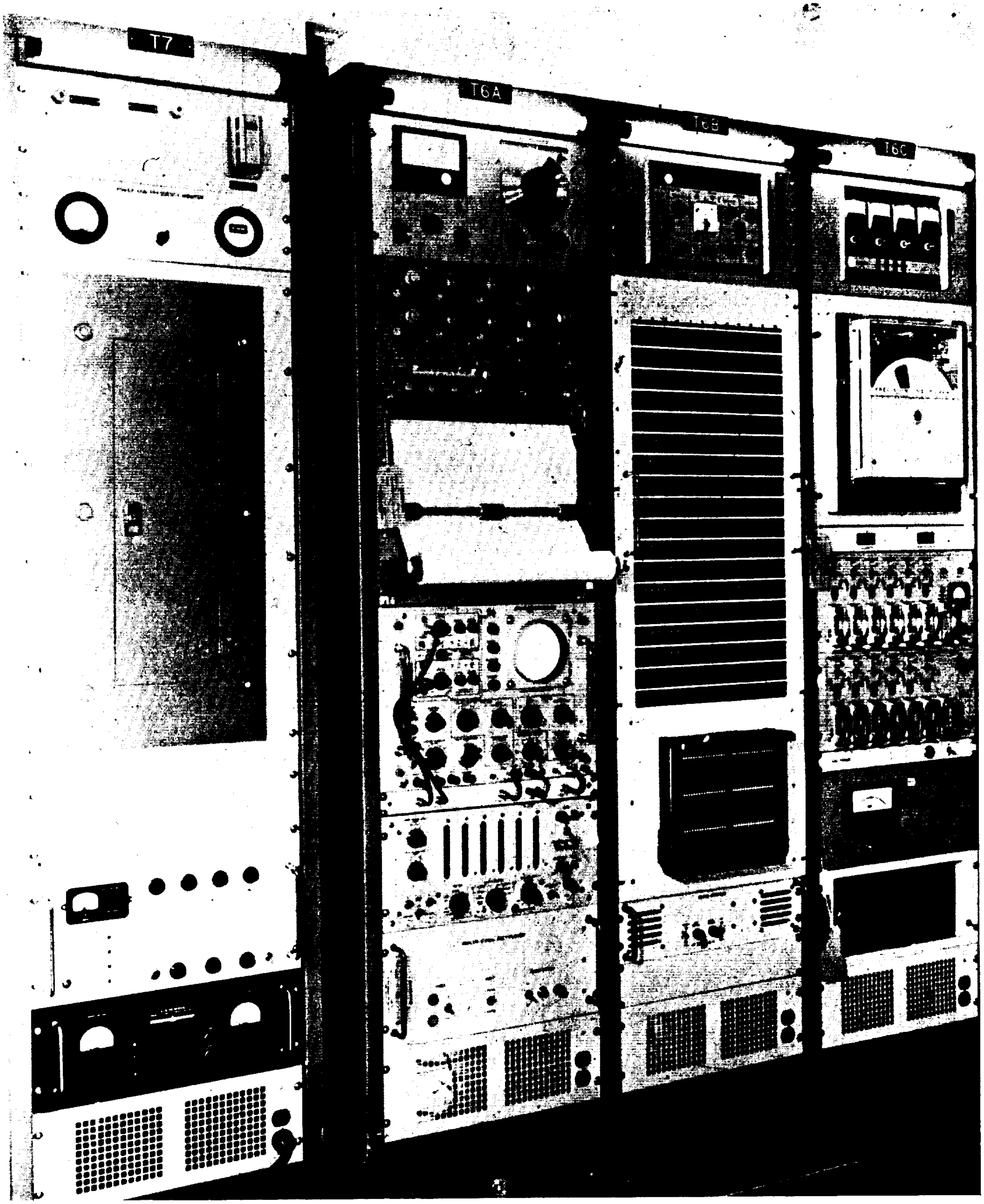


Figure 17 STRIP CHART AND MAGNETIC TAPE RECORDER

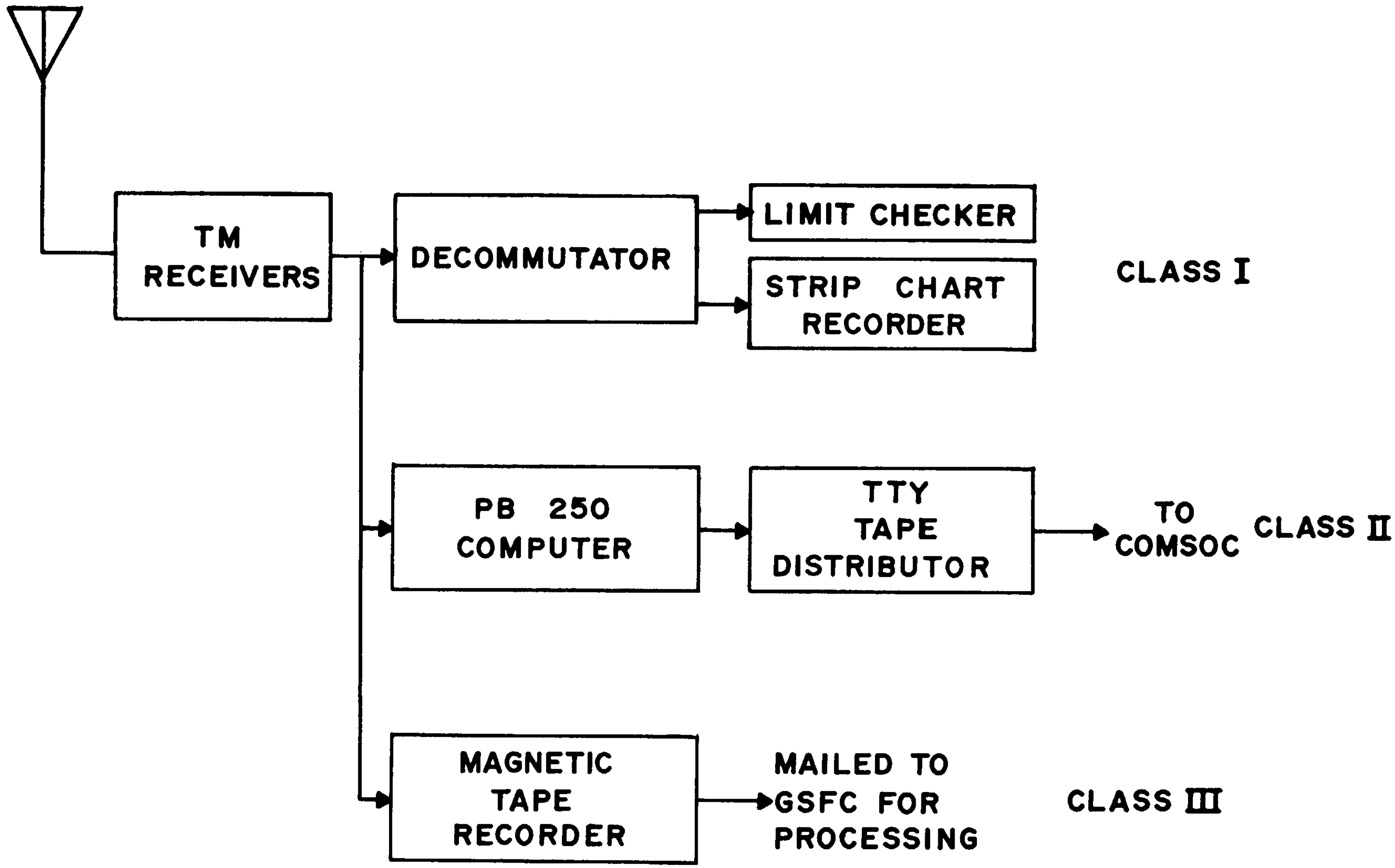


FIGURE 18 TELEMETRY FLOW DIAGRAM

CLASS I DATA

TELEMETRY WORD	ITEM	SAMPLE RATE
18	SOLAR CELL BUS VOLTAGE	1/SEC
20	TOTAL BATTERY CURRENT	1/SEC
21	COMMAND VERIFICATION JKL	1/SEC
24	*MAIN IF AGC VOLTAGE	1/SEC
28-11	*RADIATION EXPERIMENT REGULATED BUS	1/64 SEC
28-16	*TRANSPONDER REGULATED BUS	1/64 SEC
28-17	*BATTERY NO. 1 VOLTAGE	1/64 SEC
28-24	*TWT POWER OUTPUT	1/64 SEC
28-35	COMMAND VERIFICATION ABC	1/64 SEC
28-43	COMMAND VERIFICATION DEF	1/64 SEC
28-51	COMMAND VERIFICATION GHI	1/64 SEC
28-58	*BATTERY 3-2 TEMPERATURE	1/64 SEC

*ITEMS FURTHER PROCESSED THROUGH LIMIT CHECKER

Figure 19

CLASS II DATA

TM WORD	ITEM	TM WORD	ITEM
18	SOLAR CELL BUS VOLTAGE	28-24	TWT OUTPUT POWER
19	UNREGULATED BUS	28-25	BATTERY NO. 2 VOLTAGE
20	TOTAL BATTERY CURRENT	28-26	BATTERY #1-2 TEMPERATURE
21	COMMAND VERIFICATION JKL	28-27	TM XMTR #2 POWER OUTPUT
22	ACTIVE THERMAL CONTROLLER SENSOR TEMP	28-32	BEACON OUTPUT POWER
24	WB-AGC-MAIN IF	28-33	BATTERY NO. 3 VOLTAGE
26	NB SIGNAL PRESENT	28-34	BATTERY #2-1 TEMP
28- 2	SOLAR PANEL 4A-1 TEMP	28-35	COMMAND VERIFICATION ABC
28- 3	BATTERY PRESSURE, NOS. 1, 2, 3	28-41	SOLAR CELL BUS CURRENT
28- 4	VOLTAGE LIMITER CURRENT	28-42	BATTERY #2-2 TEMP
28- 5	TWT #1 POWER SUPPLY	28-43	COMMAND VERIFICATION DEF
28- 7	THERMISTOR NO. 4 TEMP	28-44	WIDEBAND BASEPLATE TEMP
28-10	SOLAR CELL PANEL 4A-2 TEMP	28-47	XMTR L.O. OUTPUT
28-11	RADIATION EXPT REGULATED BUS	28-50	BATTERY #3-1 TEMP
28-12	TWT COLLECTOR TEMP	28-51	COMMAND VERIFICATION GHI
28-13	PWR. SUPPLY #2 TEMPERATURE	28-55	TRANSMITTER INPUT SIGNAL POWER
28-16	REGULATED BUS VOLTAGE	28-58	BATTERY #3-2 TEMP
28-17	BATTERY NO. 1 VOLTAGE	28-59	COMMAND RECEIVER AGC
28-18	BATTERY #1-1 TEMPERATURE	4,5,6	RADIATION MONITOR "A"
28-19	TM XMTR NO. 1 POWER OUTPUT	16-17	SUN ASPECT INDICATOR
28-21	LOWER SURFACE TEMP	29-128-2-7	SOLAR CELLS S-1 TO S-6

Figure 20

```
02 19/0  03 /52  04 3.41  05 8/38  07 .01
  N63115214635 24.60 24.60 3/37 1.82 9/41 2.57
10 23/8  11 .10  12 11/9  13 11/8  16 22/8
17 24.9  18 3/91  19 -200/  21 -3/51  24 2.42
  N63115214651 24.51 24.51 3/28 1.82 9/35 2.57
25 4.56  26 8/67  27 241/  32 1.57
33 24.9  34 1/89  35 .73
  N63115214707 24.48 24.56 3/45 1.83 9/38 2.58
41 /96  42 3/55  43 .73  44 5/23  47 1.76
50 8/19  51 4.30  55 .20
  N63115214723 24.53 24.60 3/27 1.82 9/50 2.58
58 8/59  59 61/4
033 031 031 094 086 091 093022771 27 .78
```

CLASS II DATA FORMAT

Figure 21

If one considers a typical block starting with the symbol 02, this designator (02) is the channel number on the submultiplexer of word 28. The remainder of the first line includes subcom words 3, 4, 5 and 7. The next line contains the date time group printout with the main frame words. The letter N preceding the numbers refers to the station, in this case COMCON, where the data was received and reduced. In the same line, 63 is the year, 115 is the day of the year, 21 is the hour, 46 is the minute of the hour and 35 the second within that minute. The word immediately following the date time group in the sample shown (Figure 21) is main word 18, solar cell bus voltage which is reading 24.60 volts. The next word is the unregulated bus voltage main word 19 reading the same value. The remaining words in this line consist of main word 20 total battery current, main word 21, command verification voltage JKL, main word 22, active thermal control sensor temperature and main word 24 AGC main IF voltage which are reading 3.37 amps, 1.82 volts, 9.41°C and 2.57 volts respectively. The last line of the sample given gives the output of 6 solar cells in the solar cell experiment, the proton total count of detector A of the radiation experiment package, the sun aspect indicator output and main word 26 which is the narrowband signal presence indication. The first 3 readings of this line beginning with 033, 031 and 031 are the output in millivolts of 3 solar cells which are identical to those used in the Relay main solar bus but which have no shielding. The item beginning with 094, 086, 091 are the output of 3 identical cells but with 30 mils of shielding. The proton counter detector A is reading 093022771 counts, and the sun aspect indicator output is 27 which is the decimal equivalent of a 6 digit binary output equivalent to a sun aspect of 10.2° from the equator of the satellite. The last reading, .78, is the narrowband signal presence indication main word 26. The symbol (/) in place of the decimal point indicates that the linear calibration data should be checked for precise interpretation of the number given.

There is approximately a 19 second delay between the time that these measurements are made in the spacecraft and printed out in COMSOC. This extremely short time delay makes the printout for all practical purposes in real time. This allows monitoring of battery discharge characteristics in real time, so one can command the transponder off should the spacecraft exceed lower acceptable voltage limits. It allows real time evaluation of the received signal strength from the ground stations in terms of the main IF AGC so it is readily discernible if a ground station is adequately transmitting the proper power level or if troubles are being encountered in tracking the spacecraft. Monitoring of the radiation experiment and wideband transponder regulated bus voltage which are subcom words 11 and 16 respectively, gives real time indication that these systems are either on or off and how well the regulated outputs are maintaining the required voltage level.

The RELAY command system uses the standard NASA command format with PCM/PDM/AM modulation which is compatible with all NASA Minitrack stations. However, as previously mentioned, command of the spacecraft is performed by the test stations to ensure real time control. Figure 22 shows the command encoder console at the test station. The transmitted commands sent to the spacecraft are verified by a printout on the two channel chart recorder that can also be seen in Figure 22.

In addition to exercising command over the spacecraft and providing real time telemetry for COMSOC, the test stations have the capability of transmitting and receiving communication data. Figure 23 is a picture of the wideband transmitter and is capable of transmitting a power of 10 KW. A variety of pre-selected test signals are transmitted to the spacecraft and received at COMCON for real time subjective examination. Figure 24 shows the wideband test console which is used in the conduct of the experiments. Eighteen (18) different tests signals can be transmitted, received and analyzed. The console has the feature of a rapid switching capability which automatically switches the proper test channels in the console and displays results on the appropriate scopes and the TV monitor. This can be done in such a short period of time that a full sequence of 18 positions can be conducted during the course of a normal 30 minute wideband pass. This capability allows the test station to do real time evaluation of the wideband transponder either prior to turning it over to a formal communication station for the conduct of an experiment or during a pass which is expressly scheduled for testing by COMCON. Further, during passes in which critical experiments are being conducted by other communication stations, the test station is capable of receiving these transmissions to monitor the performance of the wideband subsystem. A microwave link is used between COMCON and COMSOC to provide a display of the communications test being conducted so they may also be monitored as an aid to making the necessary decisions on whether experiments should be scrubbed because of poor conditions of the transponder. Continual examination of the transponder over a period of time will also lead to being able to detect deterioration of the system with respect to time, however, to date, after four months of operation, no apparent deterioration of the wideband system exists. The test positions and the experiments they represent are listed in Figure 25. Figure 26 shows a typical differential gain measurement test signal transmitted and received by COMCON. Figures 27 and 28 show some typical wideband demonstrations between Europe and the U.S. that were monitored by COMCON and COMSOC.

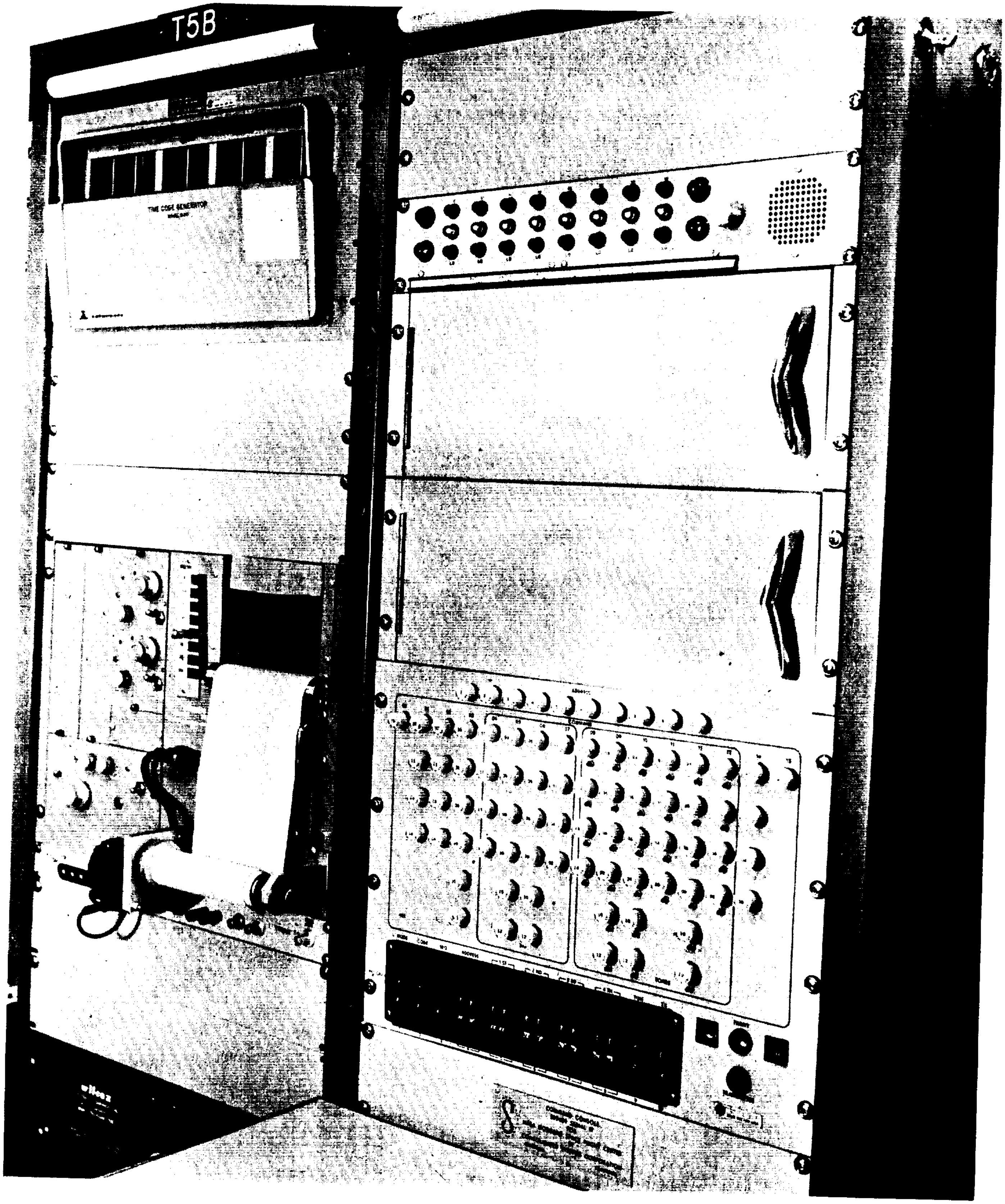


Figure 22 COMMAND ENCODER

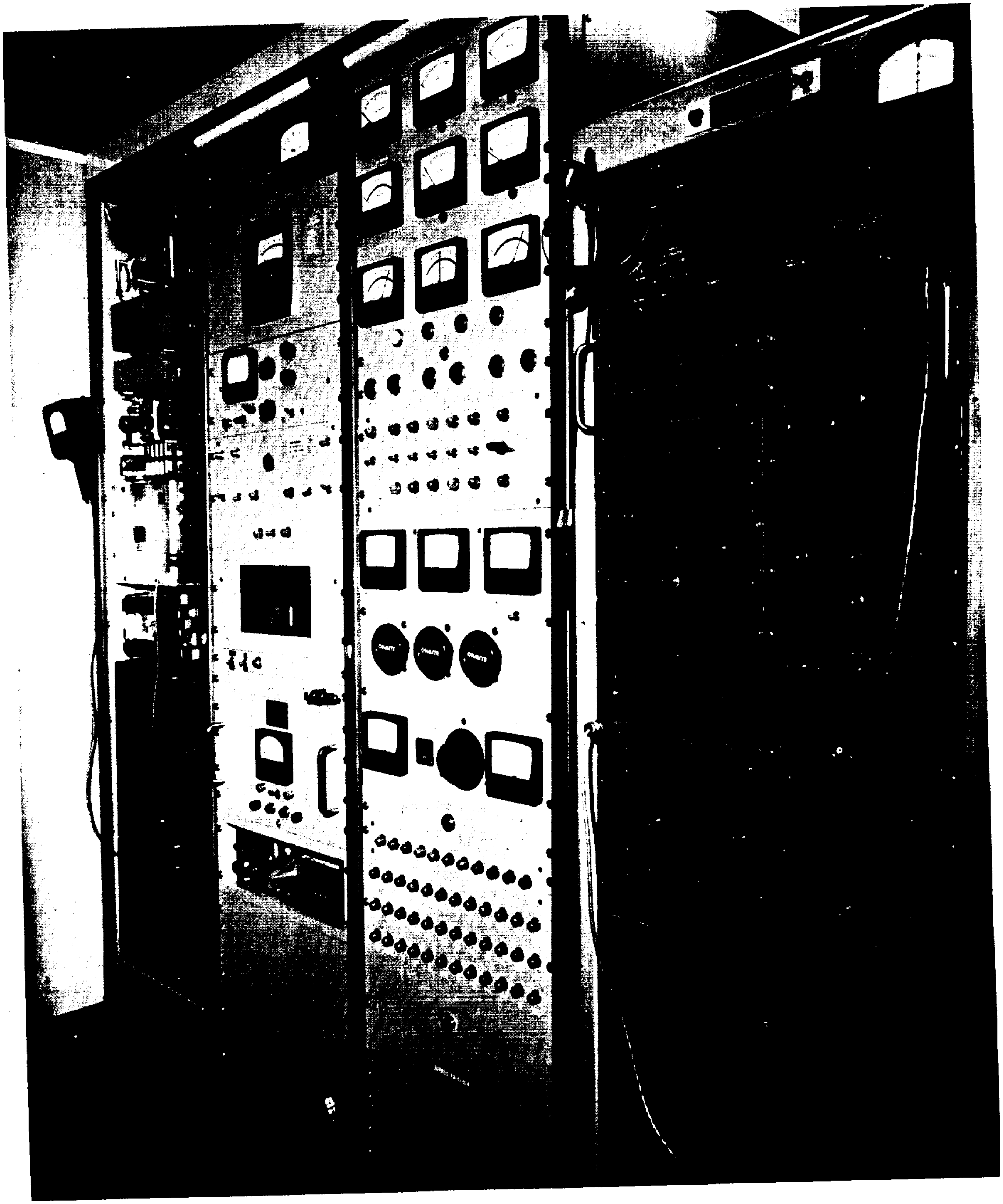


Figure 23 WIDEBAND TRANSMITTER

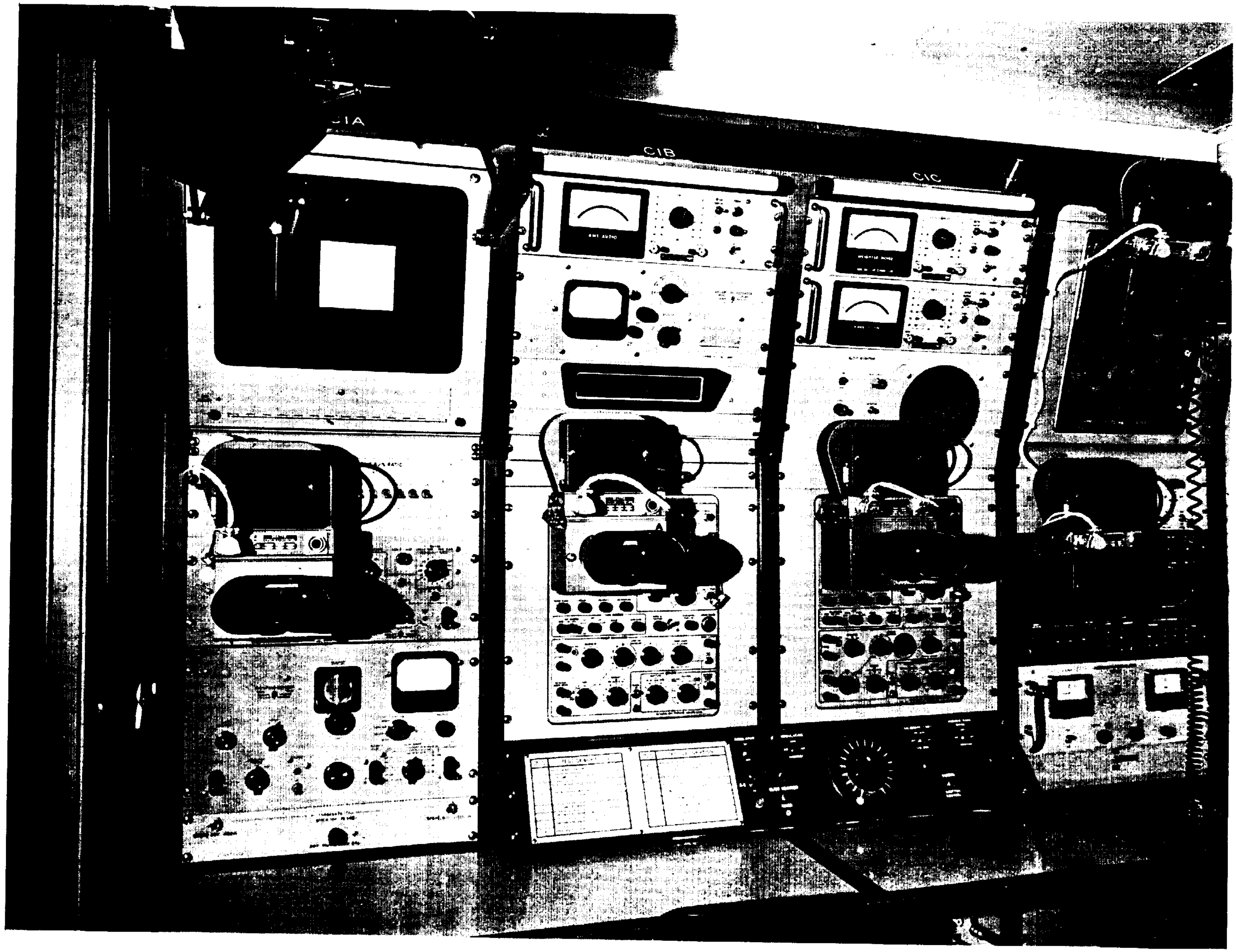
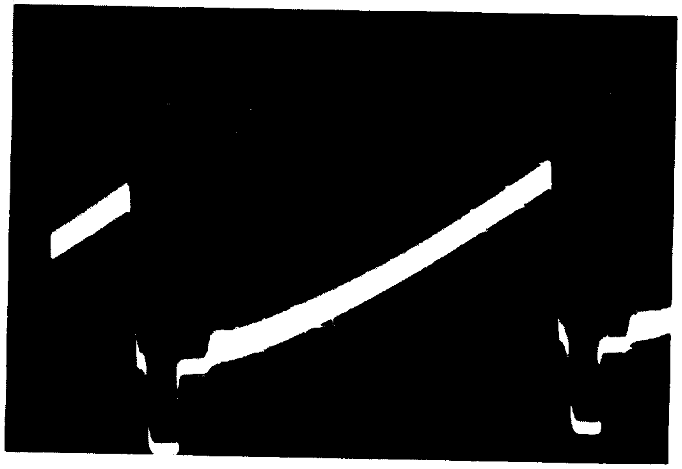


Figure 24 WIDEBAND TEST CONSOLE

WIDEBAND TEST CAPABILITIES

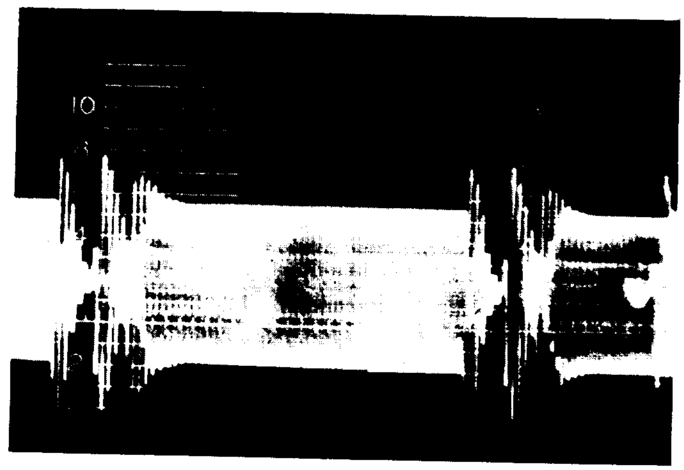
Test Position	Experiment
1	Insertion Gain
2	Short-Time Distortion "T"
3	Short-Time Distortion "2T"
4	Continuous Random Noise
5	Television Slides
6	Field Time Distortion
7	Line-Time Non-Linearity
8	Stairstep
9	Bandpass Characteristics-Baseband
10	Envelope Delay Distortion
11	Synchronization Non-Linearity
12	Periodic Noise
13	Impulsive Noise
14	Fluctuation Noise
15	Fluctuation Noise
16	Fluctuation Noise
17	Fluctuation Noise
18	Multiburst Pattern

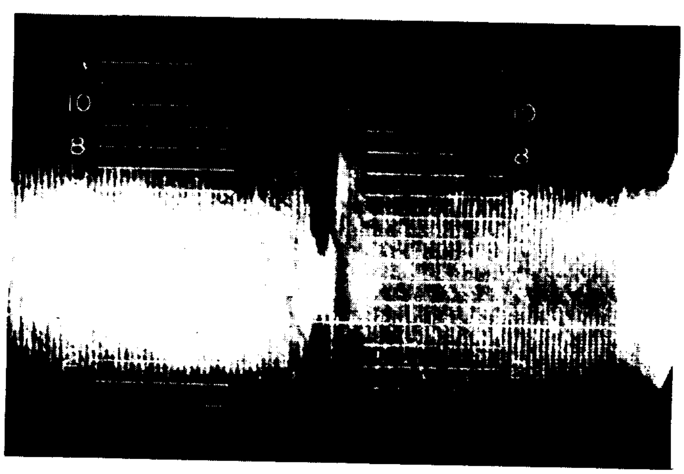
Figure 25



transmitted signal

calibration
received signal





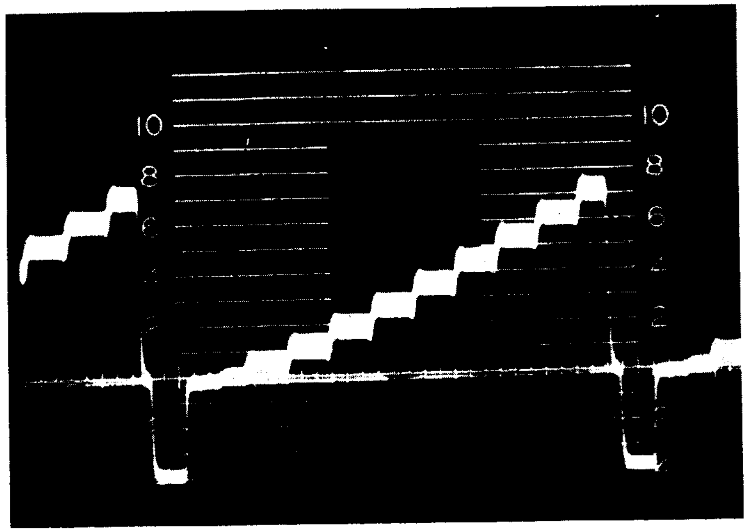
received signal

Figure 26

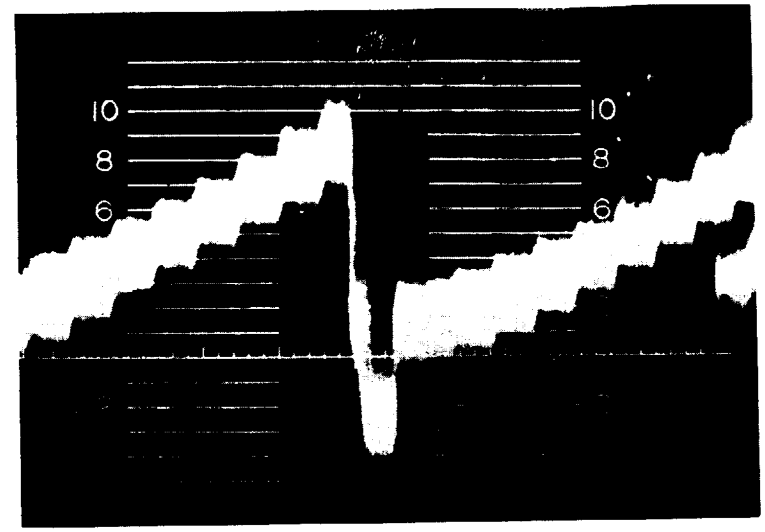
Figure 27 TELEVISION DEMONSTRATION MONITOR

Figure 28 TELEVISION DEMONSTRATION MONITOR

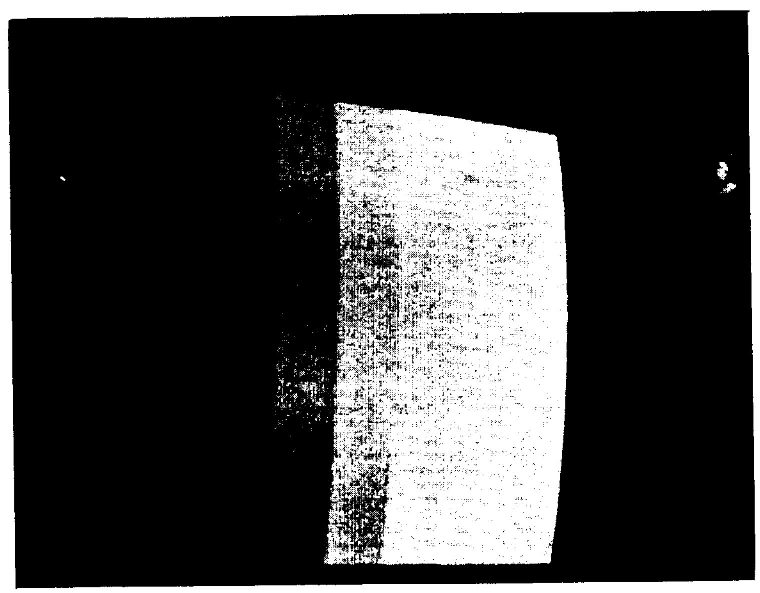
The test station at Mojave, COMMOJ, also has a wideband reception capability and this allows for communication experiment testing between the two test stations. When it is desirable to investigate specific areas in considerable detail and when participating stations are not available for experiments the test stations are used as the communication site. Figure 29 shows a stairstep test signal transmitted and received at COMCON and the resulting monitor presentation as received at COMMOJ. Figure 30 shows other COMCON test transmissions which were received at COMMOJ for subjective analysis.



Transmitted Signal from COMCON

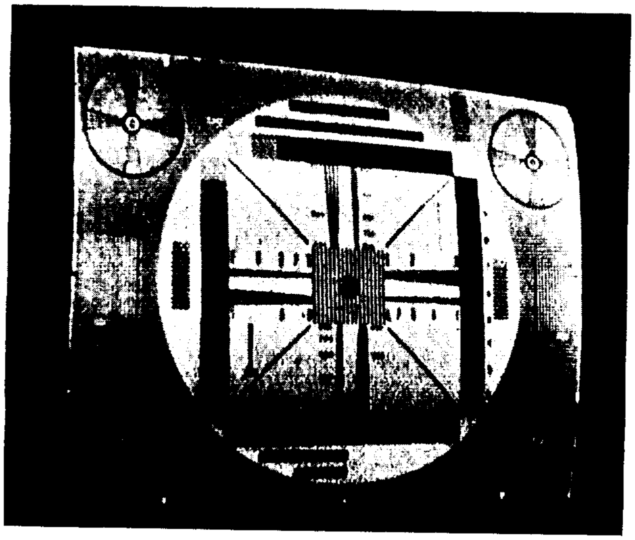


Received Signal at COMCON



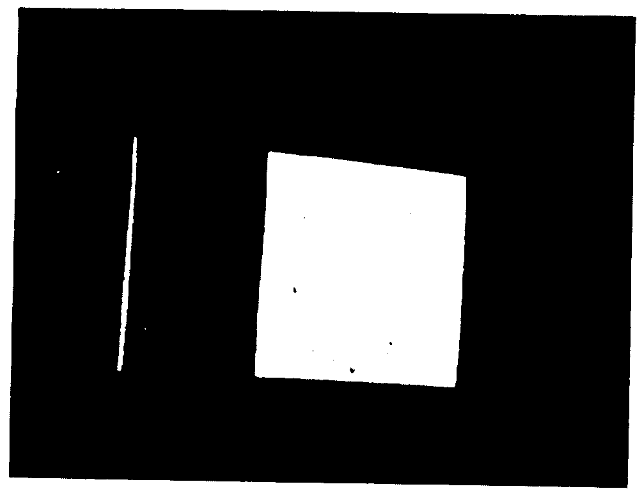
Monitor Presentation of
Received Signal at COMMOJ

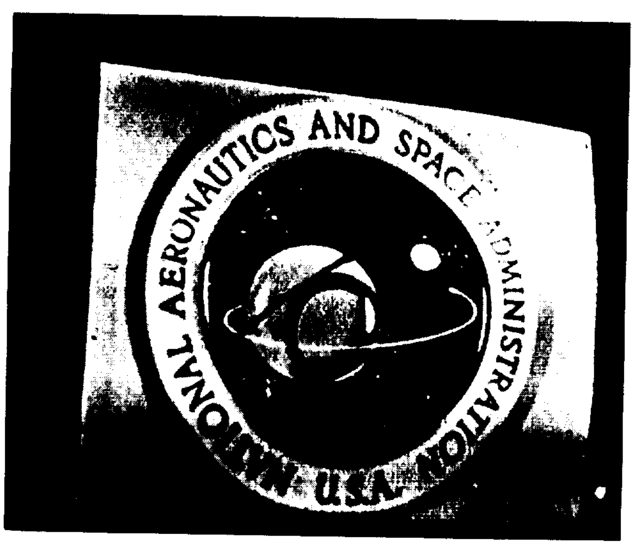
Figure 29



Test Pattern

Pulse and Bar Waveform





NASA Seal

Figure 30

ACKNOWLEDGEMENTS

The successful conduct of the operations described in this paper represent the efforts of Mr. Wendell S. Sunderlin of Goddard Space Flight Center, responsible for Overall Operations on Project RELAY, Mr. John B. Flaherty of Goddard Space Flight Center, responsible for Ground Station Coordination, and Mr. Donald E. Kendall of Space Technology Laboratories, Inc., responsible for Operations Planning and the Day by Day Orbit Operations.